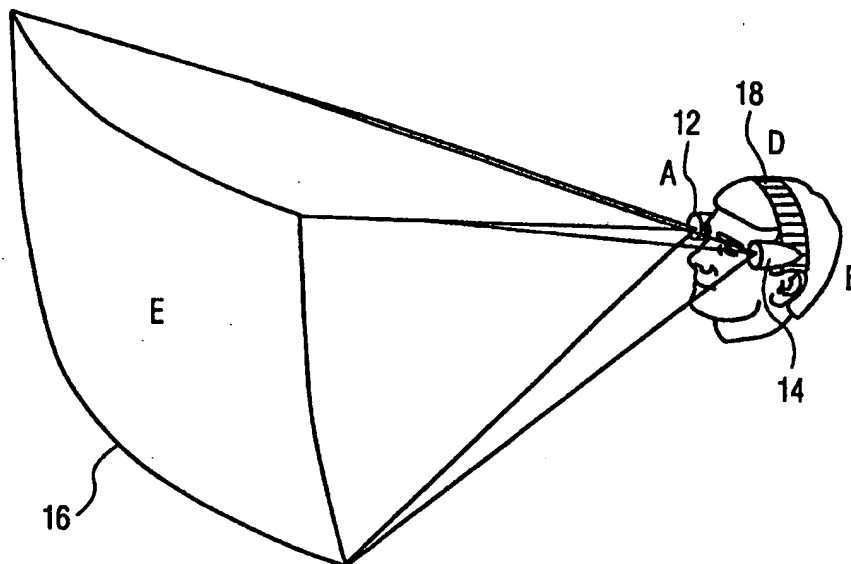




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : G02B 27/01	A1	(11) International Publication Number: WO 00/34818 (43) International Publication Date: 15 June 2000 (15.06.00)
(21) International Application Number: PCT/EP99/09188 (22) International Filing Date: 24 November 1999 (24.11.99) (30) Priority Data: 09/206,436 7 December 1998 (07.12.98) US (71) Applicant: KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (72) Inventor: STANTON, Douglas, A.; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). (74) Agent: GROENENDAAL, Antonius, W., M.; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).		(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report.

(54) Title: HEAD-MOUNTED PROJECTION DISPLAY SYSTEM



(57) Abstract

A head-mounted projection display system is characterized by a pair of head-mounted low-power image projectors mounted adjacent the eyes of the viewer, and aimed to project in a direction along the line of sight of the viewer toward a high-gain, retro-reflective screen (16). Stereoscopic viewing is enabled by projecting separate images to the right and left projectors. The retro-reflectivity of the screen (16) ensures that the right and left images will be returned to the right and left eye, respectively.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

Head-mounted projection display system.

This invention relates to a head-mounted projection display system, and more particularly relates to such a display system in which the display is stereoscopic.

5

A variety of head-mounted displays are in use or have been proposed. Usually they involve a CRT or a spatial light modulator coupled to a source of light to create the display image. In the simplest versions, the images are viewed directly by the eye, assisted by suitable optics. See, for example, Japanese Kokai 4-34588(A). Some versions permit the
10 ambient environment to be viewed through the apparatus while information is added to the observer's view from the display. See, for example, U.S. patent 5,677,795.

In UK patent application GB 2 043 940 A, a ground-based craft-flight simulator is described, in which separate right and left light beams from a laser-scanning image
15 generator are fed to right and left projection lenses mounted on a helmet above the eyes of a wearer-trainee, and projected onto a retro-reflective viewing screen. A diffraction grating on the front of the screen adjusts the angle of the retro-reflected image, so that the projected beams are reflected onto a plane mirror mounted on the helmet between the projection lenses and the eyes of the viewer. Motors mounted on the helmet rotate the mirror, to achieve
20 scanning of the reflected light beams onto the screen to build up the display image.

A drawback of the known system is that it is complex and would be expensive to implement, limiting its applicability to specialized uses such as military or commercial pilot training.

25

Accordingly, it is, inter alia, an object of the invention to provide a simple, low-power, head-mounted projection display system.

Thereto, a system according to the invention is defined in Claim 1.

A simple low-power, head-mounted projection display system, particularly one which provides stereoscopic viewing, would be useful in a variety of applications, notably virtual reality systems, useful, for example, in education, training, and/or entertainment.

5 In accordance with one aspect of the invention, there is provided a head-mounted projection display system comprising head gear including at least one low-power projector positioned such that the images from the projector are directed away from the viewer's eyes. More specifically, the projector is mounted so as to project an image in a direction along the viewer's line-of-sight. Preferably, a pair of projectors are mounted on
10 opposite sides of the head gear, adjacent the viewer's eyes, and each projector is aimed to project an image in a direction along the viewer's line-of-sight.

A further advantage of the system according to the invention is that stereoscopic viewing is possible.

15 Further aspects of the invention are defined in the dependent Claims.

The projected image is directed to a high-gain, retro-reflective viewing screen, which returns light from the low power projector(s) at sufficient brightness for the viewer to see the projected image(s). Due to the small angle of return (on the order of about 1-2
20 degrees), each eye sees only the image from its adjacent projector, enabling stereoscopic viewing in the event that separate images are projected by each projector, without the attenuation, temporal or optical manipulation common to known stereoscopic display systems.

The retro-reflective viewing screen is capable of having a wide viewing angle.
25 This characteristic, together with the retro-reflectivity of the screen, permits a single viewer or multiple viewers, each with their own headgear, to see the same image or different images at large angles of view without significant degradation, making possible, for example, one or more viewers moving within the viewing space, or an audience of stationary viewers.

These and other, more detailed, aspects of the invention will now be described
30 and illustrated with reference to the Figures.

Fig. 1 is a perspective view of one embodiment of the projection system of the invention, including a pair of low power projectors mounted on headgear, and a high-gain, retro-reflective screen;

5 Fig. 2 is a schematic cross-section view of one of the low power projectors of Fig. 1;

Fig. 3 is a detailed cross-section view of a portion of the screen of Fig. 1; and

Fig. 4 is a schematic representation of a spherical viewing room with transparent floor in accordance the invention.

10

In Fig. 1, two low power projectors 12 and 14 are mounted on the viewer's head close to each eye. Each projector is aimed at the viewing screen 16 along the direction of the line of sight of the adjacent eye of the viewer. The projectors 12 and 14 are stabilized and referenced to the viewer's head by means of a headband 18. Possible alternative headgear
15 include a hat or helmet.

The projectors each include a light source 20, an electro-optical light modulator 22, such as an LCD, and a projection lens 24, in the arrangement shown schematically in Fig. 2. Light may alternatively be supplied from a remote light source, e.g., via optical fibers.
20 Display information, such as video or computer generated display signals, are supplied to the modulator 22 via electrical cables, not shown.

The viewing screen 16 is retro-reflective. That is, it returns all incident light back to the source within a narrow angle (about 1-2 degrees). Consequently, regardless of
25 changes in the angle of incidence of the projected image caused by movement of the viewer's head, the screen will return the projected image to the viewer. The viewing screen also advantageously can have a very high gain, as high as 1600, for example, enabling the viewer to see the projected image at adequate brightness, despite the low power of the projectors. This low power not only reduces the cost of the system relative to more complex high power
30 systems, but also enables the use of battery powered operation, introducing portability and the possibility of inputting display information, such as computer generated information, by wireless link.

Depending upon the application, the screen could cover a portion of a wall or an entire wall or room. The walls of the room could be curved, e.g., cylindrical or spherical. For example, Fig. 4 shows a spherical room 40 enclosing a transparent floor 42 and viewer 44. In the stereoscopic mode of the invention, such a room 40 could be used to project images 46 and 48 above and below viewer 44, for example, to train astronauts, since it would create a perception of floating in space.

In one embodiment, shown in Fig. 3, the screen is composed of a surface of an array of uniformly sized microspheres 30, adhered to a substrate 34 by a reflective paint 32. The microspheres can be of any size above the wavelength of the light, and can also be of varying sizes. One way of constructing a large screen surface would be to blow the microspheres onto a substrate having a previously applied tacky base, e.g., wet reflective paint. As is known, one alternative to reflective microspheres is the so-called corner cube. Retro-reflective screens are also commercially available. Two examples are the 3M Special Effects Projection screens #7610 and #7615.

The invention has been described in terms of a limited number of embodiments. Other embodiments, variations of embodiments and art-recognized equivalents will become apparent to those skilled in the art, and are intended to be encompassed within the scope of the invention, as set forth in the appended claims.

CLAIMS:

1. A head-mounted projection display system comprising viewer headgear and a projection display screen (16), the headgear comprising at least one display image projector (12,14), and means (18) for mounting the projector adjacent an eye of the viewer in a manner to project an image in the direction of the line-of-sight of the viewer, and the screen (16) being
5 a retro-reflective screen.
2. The head-mounted projection display system of claim 1 in which the headgear comprises two projectors (12,14) mounted on opposite sides of the headgear.
- 10 3. The head-mounted projection display system of claim 1 in which the projection screen (16) comprises an array of reflective microspheres (30) on a substrate (34).
4. The head-mounted projection display system of claim 3 in which the substrate (34) is curved.
15
5. The head-mounted projection display system of claim 3 in which the substrate (34) is the wall of a room.
6. The head-mounted projection display system of claim 4 in which the substrate
20 (34) is spherically or hemispherically shaped.
7. The head-mounted projection display system of claim 5 in which the substrate is a spherically shaped room (40) enclosing a transparent floor (42).
- 25 8. The head-mounted projection display system of claim 1 in which the low power projector comprises an electro-optical light modulator (22) and a projection lens (24).
9. The head-mounted projection display system of claim 8 in which the electro-optical light modulator (22) comprises an LCD.

1/2

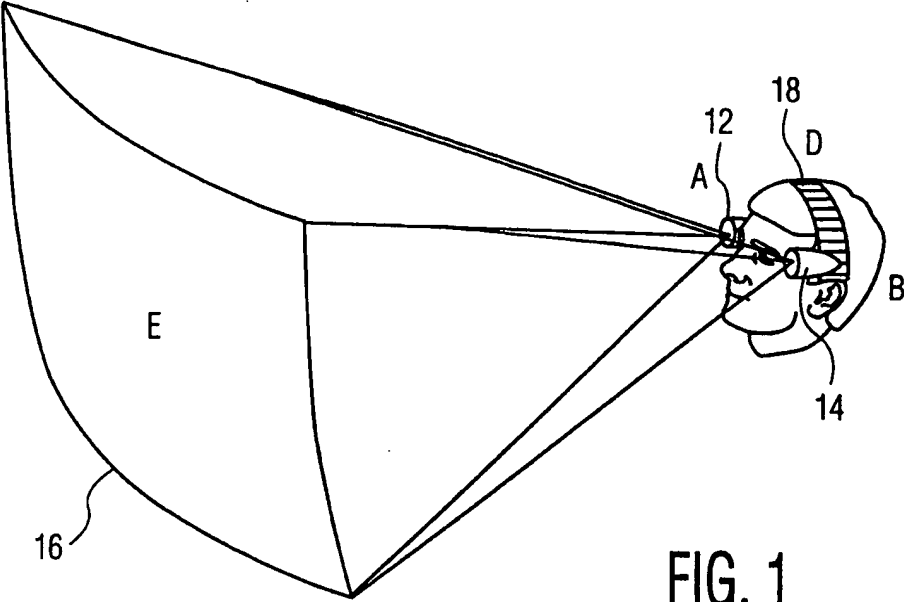


FIG. 1

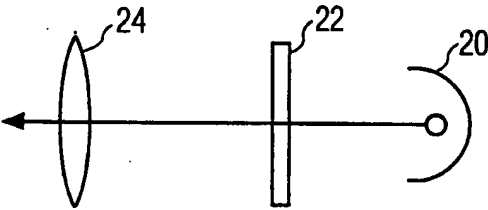


FIG. 2

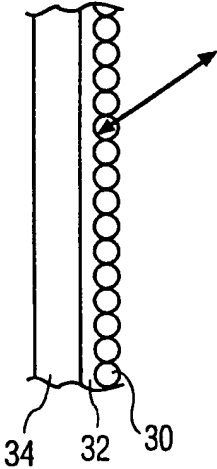


FIG. 3

2/2

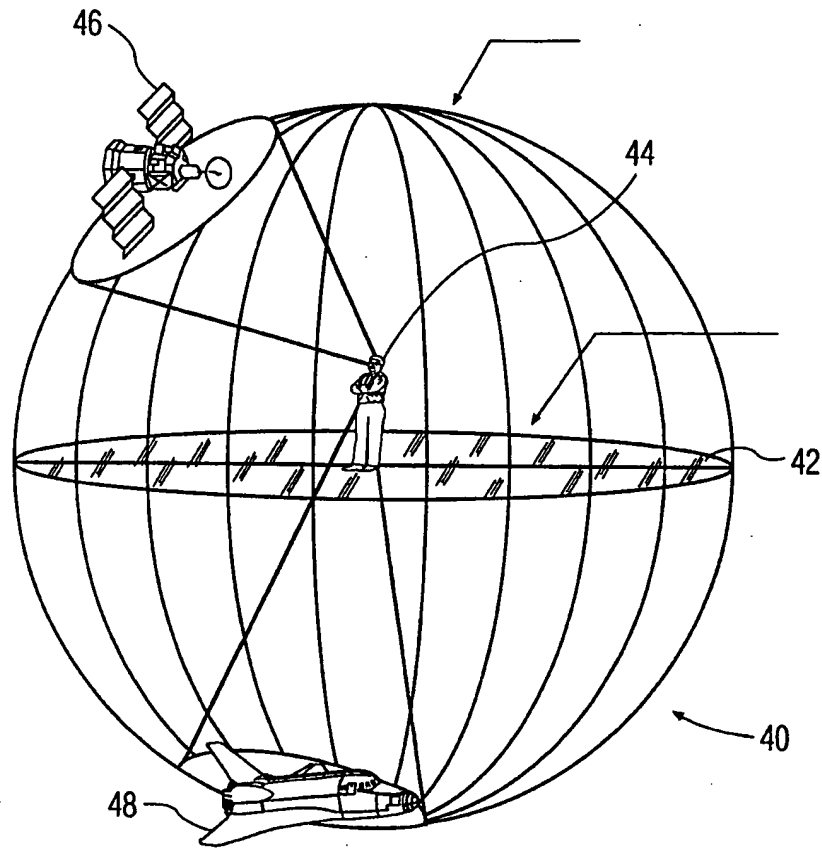


FIG. 4

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G02B27/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 92 18971 A (EVANS & SUTHERLAND COMPUTER) 29 October 1992 (1992-10-29) page 8, line 2 - line 6; figure 1 page 9, line 1 - line 4	1,2
A	page 9, line 23 - page 11, line 3; figures 3,4	4
A	US 5 189 452 A (HODSON JAMES M ET AL) 23 February 1993 (1993-02-23) column 1, line 31 - line 35 column 2, line 61 - line 67; figure 1	3,4
A	GB 2 043 940 A (REDIFON SIMULATION LIMITED) 8 October 1980 (1980-10-08) cited in the application abstract; figure 1	4
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

3 February 2000

Date of mailing of the international search report

10/02/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Soulaire, D

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 052 932 A (TRANI) 1 October 1991 (1991-10-01) column 3, line 46 - line 55; figures 1,3 ----	5-7
A	US 5 130 794 A (RITCHEY) 14 July 1992 (1992-07-14) column 15, line 59 -column 16, line 23 column 31, line 67 -column 32, line 2; figures 36,46 ----	7
A	WO 91 04508 A (GENERAL ELECTRIC COMPANY) 4 April 1991 (1991-04-04) page 6, line 19 - line 24 page 9, line 7 - line 14; figures 1A,2 ----	8,9
A	US 5 677 795 A (HEGG) 14 October 1997 (1997-10-14) cited in the application abstract column 4, line 6 - line 18; figures -----	2

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9218971 A	29-10-1992	CA 2085735 A DE 4291016 T FR 2675613 A GB 2261804 A JP 6502054 T US 5572229 A	23-10-1992 13-05-1993 23-10-1992 26-05-1993 03-03-1994 05-11-1996
US 5189452 A	23-02-1993	NONE	
GB 2043940 A	08-10-1980	CA 1119854 A US 4340274 A	16-03-1982 20-07-1982
US 5052932 A	01-10-1991	NONE	
US 5130794 A	14-07-1992	NONE	
WO 9104508 A	04-04-1991	EP 0443025 A JP 4501927 T	28-08-1991 02-04-1992
US 5677795 A	14-10-1997	EP 0722109 A IL 116691 A JP 2915337 B JP 8262366 A US 5835277 A	17-07-1996 22-02-1998 05-07-1999 11-10-1996 10-11-1998